

**Communications System Architecture Development  
For  
Air Traffic Management & Aviation Weather Information  
Dissemination**

Research Task Order 24

**Subtask 4.9, Develop Transition Plan  
(Task 8.0)**

Prepared By

**ARINC  
Science Applications International Corporation (SAIC)  
TRW**

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# **1 Executive Summary**

## **1.1 Background**

The Advanced Air Transportation Technologies (AATT) initiative has a number of project sub-elements ranging from advanced ATM concept development to aircraft systems and operations. It also has an Advanced Communications for Air Traffic Management (AC/ATM) task with a goal of enabling an aeronautical communications infrastructure through satellite communications that provides the capacity, efficiency, and flexibility necessary to realize the benefits of the future ATM system and the mature Free-Flight (F/F) environment. Specifically, the AC/ATM task is leveraging and developing advanced satellite communications technology to enable F/F and provide global connectivity to all aircraft in a global aviation information network. The task directly addresses the Office of Aerospace Technology (OAT) Enterprise Pillar One Enabling Technology Goal of increasing aviation throughput as part of the AATT Project. The objectives of the AC/ATM task are to:

1. Identify the current communication shortfalls of the present ATM system
2. Define communications systems requirements for the emerging AATT concept(s)
3. Demonstrate AATT concepts and hardware
4. Develop select high-risk, high payoff advanced communications technologies.

The technical focus of the AC/ATM task has centered on the development of advanced satellite communications technology as a select high-risk, high payoff technology area in support of ATM communications (objective 4 above). Although the thrust of the task has been satellite communications (SATCOM), aeronautical air-ground communications will be provided for the foreseeable future by a number of different communications systems/data links, including VHF, L-band, and SATCOM. Relevant advanced technology development for any of these systems requires that a comprehensive technical communications architecture exist. In satisfaction of objectives 1 and 2, a comprehensive technical communications system architecture must be defined and developed. That architecture must address the user communications requirements of the future mature ATM system that the various data links mentioned can support.

## **1.2 Objectives**

The objective of Task 8 is to develop a transition plan for achievement of the 2015 AATT communications architecture as defined in Task 5 of this report. The transition plan will highlight the key milestones and interdependencies that are necessary to achieve this goal.

## **1.3 Technical Approach**

The 2015 communications architecture defined in Task 5 is described functionally as a collection of technical concepts and physically as a collection of communication links. Our approach to describing a transition plan for the communication architecture was to define the key milestones and activities for implementation of each of the technical concepts and each of the communication links, followed by a summary of the system-wide cross-cutting activities that apply to the integrated systems. This approach provides a view of the activities necessary to deliver a service as well as a view of the activities necessary to establish a specific communications link to support one or more services.

#### **1.4 Results of This Task**

A collection of schedules was produced for each of the communication architecture technical concepts and for each communication link highlighting the key milestones and activities necessary for implementation. Additionally, an integrated system level schedule was produced to depict the cross-cutting milestones and activities that apply to all communication architecture efforts.

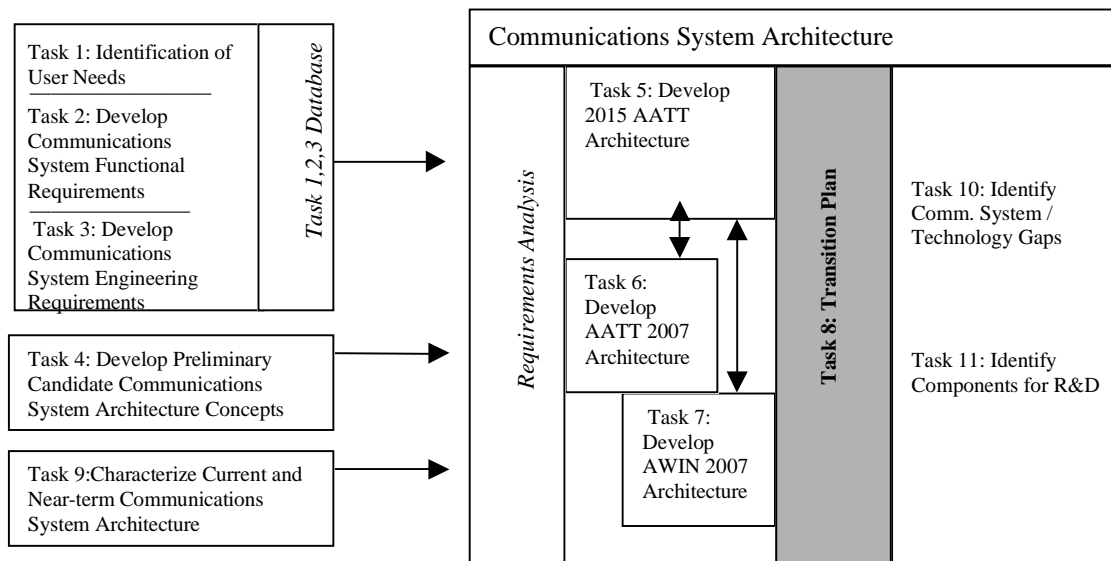
## 2 Introduction

### 2.1 Overview of Task 8

Task 8 provides a transition plan for the 2015 communications architecture identified in task 5. The transition plan identifies key milestones, activities, and interdependencies necessary to implement the communication architecture.

### 2.2 Relationship to Other Tasks

Task 8 is one of eleven related tasks in the AATT RTO 24, Communications System Architecture Development for Air Traffic Management and Aviation Weather Information Dissemination. The relationships among these tasks are depicted in Figure 2.2-1. Task 8 provides the transition plan for achieving the 2015 AATT communications architecture defined in Task 5 and identifies the research and standards activities that are necessary to address the technology gaps identified in Task 10.



**Figure 2.2-1. Relationship to Other Tasks**

### Overview of the Document

Sections 1 and 2 provide an executive summary and overview of the document. Section 3 presents the transition schedules for each of the technical concept areas and provides an integrated transition schedule for each communication link.

### **3 Transition Plan**

#### **3.1 Introduction**

The NAS is in a constant state of transition. Significant changes will occur in air-ground communications between today and 2007. Many of the systems that will begin implementation just prior to 2007 will be fully deployed by 2015. Table 3.1-1 below summarizes the significant changes that will occur in making the transition from today to 2007 and then from 2007 to 2015. Transitions that reflect the current path of the NAS Architecture are indicated as such. Those not indicated are recommended deviations from the NAS Architecture path. The Aeronautical Operation Control Data Link (AOCDL) and Airline Passenger Communication Service (APAXS) are not part of the NAS Architecture.

Transition schedules are provided first for each technical concept area and then for each communication link. Each schedule is organized into ground communications, air-ground communications, and avionics in order to highlight the activities in each of these areas necessary to deliver the service. Within each of these areas are sections for research, standards, and systems.

**Table 3.1-1. Summary of Technical Concept Transition**

<b>Technical concept</b>	<b>Today - 2007</b>	<b>2007 - 2015</b>
FIS	<ul style="list-style-type: none"><li>• Provided by commercial service provider over VDL-B [NAS Architecture]</li><li>• Possible introduction of SATCOM broadcast</li></ul>	<ul style="list-style-type: none"><li>• Migrate to SATCOM broadcast if not established by 2007</li></ul>
TIS	<ul style="list-style-type: none"><li>• Possible "local pockets" on UAT/Mode-S [NAS Architecture]</li><li>• Possible introduction of SATCOM broadcast</li></ul>	<ul style="list-style-type: none"><li>• Establish VDL-B or continue SATCOM broadcast if established by 2007</li></ul>
CPDLC	<ul style="list-style-type: none"><li>• Initial service on VDL-2 for En Route airspace [NAS Architecture]</li></ul>	<ul style="list-style-type: none"><li>• Migrate to VDL-3, transition complete for all but uncontrolled airspace by 2015 [NAS Architecture]</li></ul>
CPC	<ul style="list-style-type: none"><li>• Transition existing analog radios to digital radios broadcasting VHF-AM [NAS Architecture]</li></ul>	<ul style="list-style-type: none"><li>• Migrate to VDL-3, transition complete for all but uncontrolled airspace by 2015 [NAS Architecture]</li></ul>
DSSDL	<ul style="list-style-type: none"><li>• Begin initial service for aircraft to ATC data on VDL-2 [NAS Architecture]</li></ul>	<ul style="list-style-type: none"><li>• Migrate to VDL-3 [NAS Architecture]</li></ul>
AOCDL	<ul style="list-style-type: none"><li>• Migrate from ACARS (VDL-1) to VDL-2</li></ul>	<ul style="list-style-type: none"><li>• Continue service on VDL-2</li></ul>
ADS-B	<ul style="list-style-type: none"><li>• Implement "local pockets" on Mode-S / UAT/VDL-4 based on link decision [NAS Architecture]</li></ul>	<ul style="list-style-type: none"><li>• Evolve to national implementation on Mode-S / UAT/VDL-4 [NAS Architecture]</li></ul>
AUTOMET	<ul style="list-style-type: none"><li>• Evolve MDCRS from ACARS to VDL-2 [NAS Architecture]</li><li>• Implement AUTOMET for class 1 users on VDL-2</li></ul>	<ul style="list-style-type: none"><li>• Continue service on VDL-2 [NAS Architecture]</li></ul>
APAXS	<ul style="list-style-type: none"><li>• Evolve to next generation e.g., Ka-band SATCOM services</li></ul>	<ul style="list-style-type: none"><li>• Continue SATCOM services</li><li>• Experiment with V-band services</li></ul>

Table 3.1-2 below identifies the links that will be used by each technical concept area for each time frame. This table also illustrates the interdependencies of the technical concept areas for each communications link.

**Table 3.1-2. Technical Concept Time Frame**

Technical Concept	VHF-AM	VDL-2 / ATN	VDL-3 / ATN	VDL-4 / ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
FIS					<b>2007 2015</b>		<b>2007* 2015*</b>	<b>2007* 2015*</b>	
TIS					<b>2007 2015</b>	<b>2007*</b>	<b>2007* 2015*</b>	<b>2007* 2015*</b>	
CPDLC		<b>2007</b>	<b>2015</b>						
CPC	<b>2007 2015</b>		<b>2015</b>						
DSSDL		<b>2007</b>	<b>2015</b>						
AOC DL		<b>2007 2015</b>					<b>2007* 2015*</b>		<b>2007* 2015*</b>
ADS-B				<b>2007* 2015*</b>		<b>2007* 2015*</b>	<b>2007* 2015*</b>		
AUTOMET		<b>2007 2015</b>					<b>2007* 2015*</b>		<b>2007* 2015*</b>
APAXS								<b>2007* 2015</b>	<b>2007* 2015</b>
* Possible Implementation									

Table 3.1-3 provides a summary of functionality provided by each communications link.

**Table 3.1-3. Transition Summary by Communications Link**

Communication Link	Today - 2007	2007 - 2015
VHF-AM	<ul style="list-style-type: none"> <li>Support NAS-wide air-ground voice communication</li> </ul>	<ul style="list-style-type: none"> <li>Support air-ground communication in selected uncontrolled airspace</li> </ul>
VDL-2	<ul style="list-style-type: none"> <li>Support En Route CPDLC messaging</li> <li>Support Initial aircraft to ATC DSSDL data exchange</li> <li>Support AOC operations and maintenance data exchange</li> <li>Support AUTOMET reporting to NWS</li> </ul>	<ul style="list-style-type: none"> <li>Support AOC operations and maintenance data exchange</li> <li>Support AUTOMET reporting to NWS</li> </ul>
VDL-3	<ul style="list-style-type: none"> <li>No service in 2007</li> </ul>	<ul style="list-style-type: none"> <li>Support CPDLC messaging in all domains</li> <li>Support DSSDL data exchange for aircraft-ATC and aircraft-aircraft</li> </ul>



Communication Link	Today - 2007	2007 - 2015
VDL-4	<ul style="list-style-type: none"> <li>• Possible support for ADS-B in local pockets</li> </ul>	<ul style="list-style-type: none"> <li>• Possible support for ADS-B</li> </ul>
VDL-B	<ul style="list-style-type: none"> <li>• Support commercial delivery of FIS data</li> </ul>	<ul style="list-style-type: none"> <li>• Support commercial delivery of FIS data</li> <li>• Support delivery of TIS tactical data</li> </ul>
Mode-S	<ul style="list-style-type: none"> <li>• Support aircraft surveillance (not considered as a part of data communication function)</li> <li>• Possible support for TIS tactical data delivery to aircraft</li> <li>• Possible support for ADS-B in "local pockets"</li> </ul>	<ul style="list-style-type: none"> <li>• Support aircraft surveillance (not considered as a part of data communication function)</li> <li>• Possible support for ADS-B</li> </ul>
UAT	<ul style="list-style-type: none"> <li>• Possible support for TIS tactical data delivery to aircraft</li> <li>• Possible support for ADS-B in "local pockets"</li> </ul>	<ul style="list-style-type: none"> <li>• Possible support for ADS-B</li> </ul>
SATCOM-broadcast	<ul style="list-style-type: none"> <li>• Possible support for FIS</li> <li>• Possible support for TIS</li> <li>• Possible support for APAXS</li> </ul>	<ul style="list-style-type: none"> <li>• Support for FIS</li> <li>• Possible support for TIS</li> </ul>
SATCOM-2way	<ul style="list-style-type: none"> <li>• Possible support for APAXS</li> </ul>	<ul style="list-style-type: none"> <li>• Support for APAXS</li> </ul>

### 3.2 Transition Plans

Each of the nine technical concept areas is addressed in terms of major activities and milestones that must be met to achieve the objectives of the 2015 environment.

#### 3.2.1 Flight Information Systems (FIS) Transition

In the FIS concept aircraft receive flight information continuously to enable common situational awareness and allow pilots to operate safely and efficiently. Flight information consists of weather and NAS status information. The objective of FIS is to provide to the aircraft the most current information available. In our concept, the FAA makes flight information available to commercial service providers, who then transmit that information to aircraft that subscribe to their service.

Currently, the NAS Architecture baseline for FIS in the 2007 and 2015 time frames is to allocate up to four VHF frequencies to allow commercial service providers to deliver weather information to the cockpit via data link. As part of the FAA's FIS policy, the FAA will make NAS status and existing weather data available to commercial service providers for development of FIS products. The commercial service provider will use VDL broadcast to transmit text and graphical weather, special use airspace information, NOTAMs, and traffic flow data directly to the aircraft. Users will need to equip their aircraft with a VHF data radio (multimode radio) and a multifunction color display to receive the information.

In the 2015 time frame, we believe that non-addressed broadcast satellite technology will be the most desirable for providing flight information. This is based on our forecast that the exchange of data between the ground nodes and aircraft will increase exponentially (as it has for the past 10 years). This increase will drive the requirement for data exchange from the kilobit range to the megabit range. Given this forecast, we must look beyond the VHF spectrum toward broadband solutions that are provided via SATCOM. While dedicated ATC SATCOM solutions are most likely unaffordable, we believe that consumer demand for broadcast services in the cabin will provide the incentive for system providers to develop the receivers, antenna, and other components necessary to provide this service. Without cooperative research from the government, these designs will support high-end aircraft only.

Given the migration to broadband frequencies, the need exists for higher efficiency transmitters (both space and terrestrial), more adaptive bandwidth versus power efficient modulation, forward error correction coding (including turbo codes and bit/modulation symbol interleaving), and much expanded use of variable bit rate formats and dynamic multiplexing techniques such as asynchronous transfer mode (ATM) based technologies. Antennas and receivers must be adapted for the aviation market (size, weight, cost) and must overcome the problems of rain attenuation for broadcast FIS over satellite.

In addition to the communication gaps identified for FIS, there are ground and aircraft gaps that also must be addressed, including the development of common data standards, NWIS security routing protocols for delivery of FIS data, and data display standards for the cockpit.

The transition schedule for FIS is shown in Figure 3.2-1.

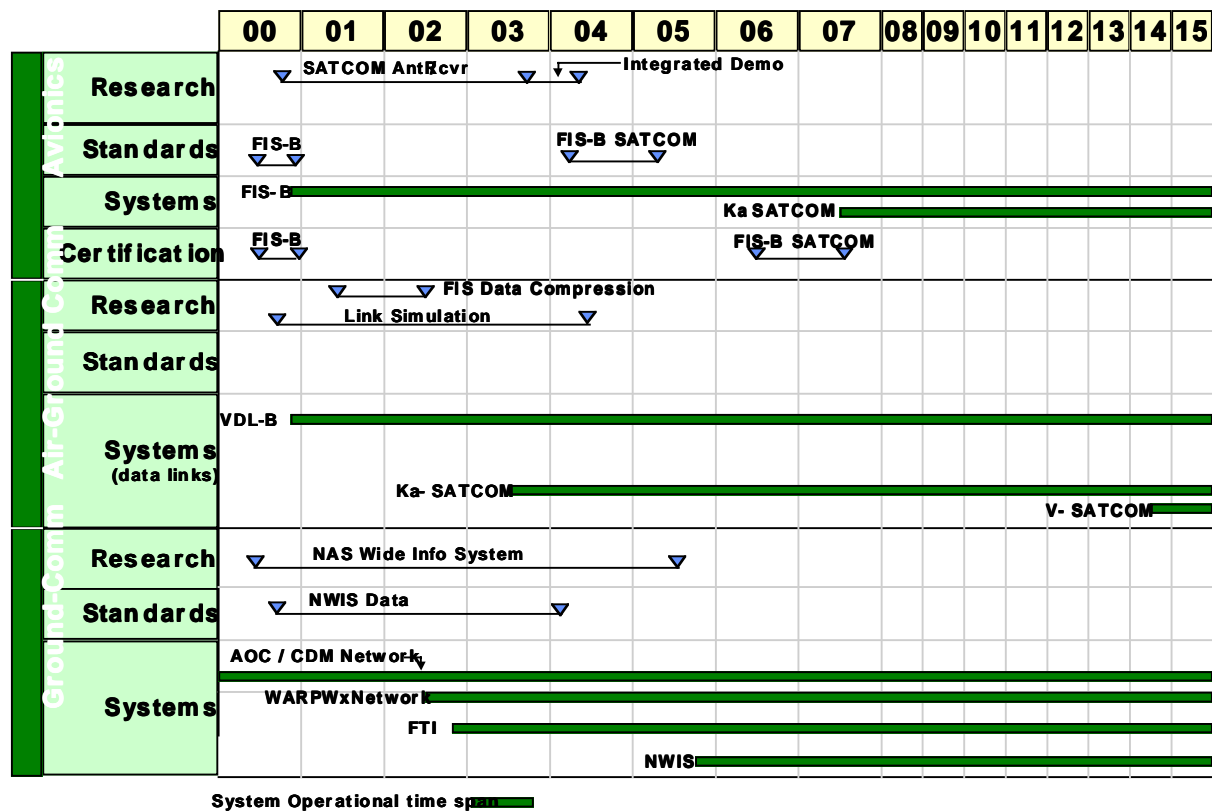


Figure 3.2-1. AATT Communication Architecture Schedule-FIS

### FIS Avionics

For FIS avionics, standards development within RTCA is currently underway in SC-195. Completion of the standard is anticipated for the end of 2000. The FIS commercial service providers are anticipated to have VDL-B avionics available for aircraft installation in the fall of 2000.

Research should begin on SATCOM solutions for FIS in the fall of 2000 with the goal of beginning an integrated demonstration of FIS delivery to the cockpit via SATCOM in the fall of 2003. Data gathered from this research would be used to develop a FIS standard for SATCOM in

the 2004/2005 time frame. This standard would drive the development and certification of SATCOM avionics in the 2006/2007 time frame.

### **FIS Air-Ground Communications**

It is anticipated that an initial ground-based VDL-B network will be in place in the fall of 2000 in selected areas. This network will utilize the FAA allocated frequencies and will grow to national coverage based on user demand.

Initial deployment of Ka-band satellites will begin in the 2003 time frame. Efforts should be made to secure channel space in order to support an integrated FIS SATCOM demonstration.

Research should be conducted in the 2001/2002 time frame to determine the improvements that can be made in the effective FIS data transfer rates through the use of data compression schemes. Additionally, link simulation research should be conducted in conjunction with the SATCOM avionics research to determine the most effective link usage/access methods required to support data transfer.

### **FIS Ground Communications**

The structure of FIS data will be influenced by the information architecture efforts for the NAS-wide information system. NWIS efforts will include the development of data standards for all operational data used within the NAS. These efforts will begin in the mid 2000 time frame. FIS data is provided to the commercial service providers via the WARP weather network that is supported by the FAA Telecommunications Infrastructure.

## **3.3 Traffic Information Service (TIS) Transition**

The TIS function is intended to improve the safety and efficiency of aircraft by providing pilots with automatic display of surrounding traffic and warning of any potentially threatening conditions. The source of the information is aircraft tracks maintained by the ground for a region of airspace. Traffic information consists of real time aircraft position data that is received by ATC from their ground-based surveillance sensor network consisting of primary and secondary radars and dependent surveillance receivers. The received aircraft position data is combined with trajectory and intent data and re-sent to aircraft. TIS information supports Cockpit Display of Traffic Information (CDTI) to provide pilots with complete traffic situational awareness. In our concept, the FAA provides traffic information to commercial service providers who then transmit that information to the aircraft.

SATCOM Broadcast may be available in the 2007 time frame due to the commercial demand for APAXS direct broadcast satellite or other services in aircraft. This availability could provide an additional benefit of supporting air traffic services such as TIS-B that would not otherwise be available. Assuming it was available, SATCOM could support the strategic portion (data latency of five minutes acceptable) of TIS for aircraft operating in the CONUS in 2007. It is expected that SATCOM will be available in the 2015 time frame.

The transition schedule for TIS is shown in Figure 3.3-1.

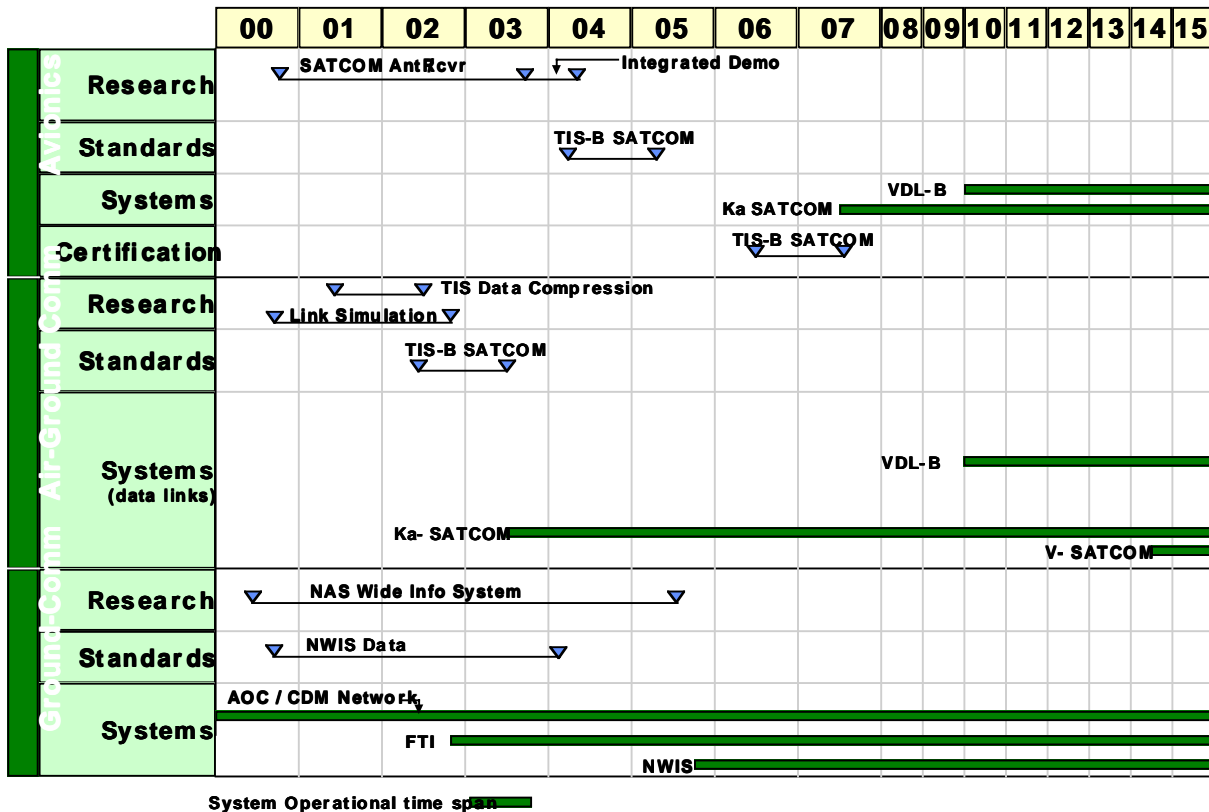


Figure 3.3-1. AATT Communication Architecture Schedule-TIS

### TIS Avionics

Some initial standards for TIS-B have been developed but they will need to be modified to be compatible with the standards that will be revised following the ADS-B link decision. With a link decision anticipated in the end of 2001, this standards work should begin shortly thereafter but no later than 2003. Avionics standards should consider the use of SATCOM based on the results of research to develop suitable SATCOM avionics and demonstrations conducted in the 2003/2004 time frame.

### TIS Air-Ground Communications

Barring successful demonstration of SATCOM capability for TIS, a terrestrial-based solution will be required. This will most likely be some form of VDL-B using VHF spectrum that is made available as a result of efficiencies realized through implementation of VDL-3.

Research should be conducted in the 2001/2002 time frame in cooperation with FIS to determine the improvements that can be made in effective data transfer rates through the use of data compression schemes. Additionally, link simulation research should also be conducted cooperatively in conjunction with the SATCOM avionics research to determine the most effective link usage/access methods required to support data transfer.

## TIS Ground Communications

The structure of TIS data will be influenced by the information architecture efforts for the NAS-wide information system. NWIS efforts will include the development of data standards for all operational data used within the NAS. These efforts will begin in the mid 2000 time frame. TIS data will be provided through the FAA Telecommunications Infrastructure.

### 3.4 Controller-Pilot Communications (CPC) Transition

Voice communication is the foundation of air traffic control. Thus, even as we move toward a higher utilization of data messaging for routine communications, it is critical to maintain a high quality, robust voice communication service. The implementation of NEXCOM will provide both digital voice and data capabilities. Radios will be able to emulate the existing analog system and select modulation techniques using software programming. As the users equip with new avionics, NEXCOM will evolve to an ATN compliant VDL-3 voice and data capability implementing Time Division Multiple Access (TDMA). TDMA uses four time slots or sub-channels within each 25 kHz channel, with an effective data transfer rate of 4.8 Kbps each.

The transition schedule for CPC is shown in Figure 3.4-1.

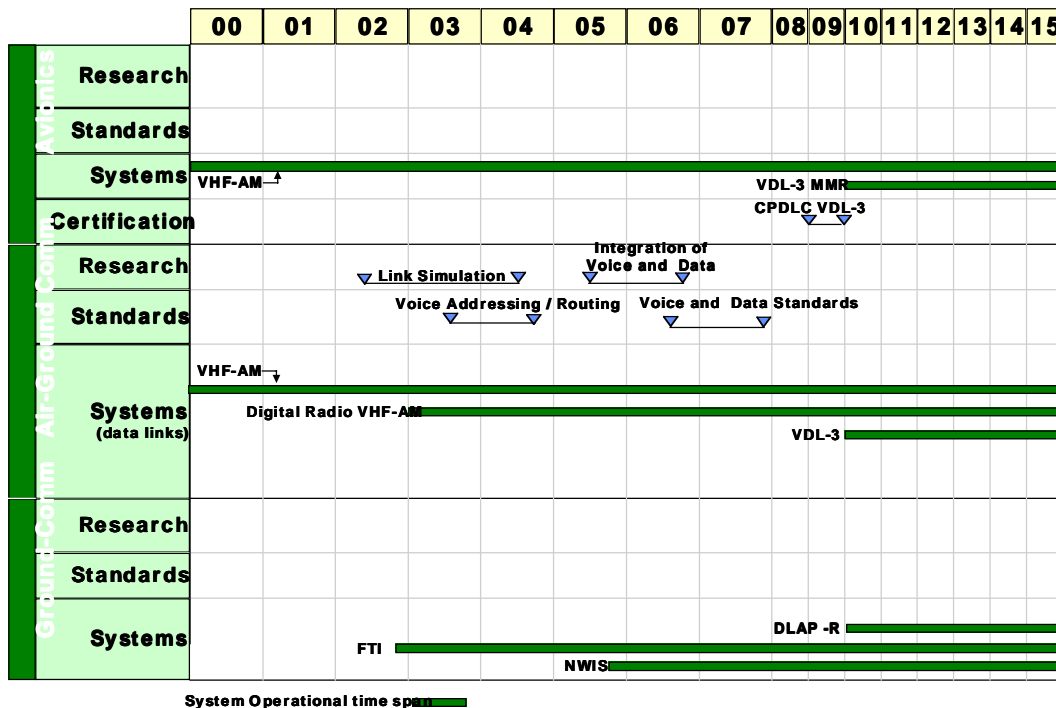


Figure 3.4-1. AATT Communication Architecture Schedule-NEXCOM

#### CPC Avionics

Aircraft avionics for voice communication remain unchanged from today's systems until the introduction of VDL-3 in the 2010 time frame. It is anticipated that the majority of users will transition to a VDL multi-mode radio in the 2010 to 2015 time frame in conjunction with the cut-over of sectors from VHF-AM to VDL-3 operation.

## **CPC Air-Ground Communications**

As part of the NEXCOM program, the current VHF-AM radios will be replaced with digital radios (that continue to broadcast VHF-AM) in the 2003 time frame. These radios will be configured for VDL-3 operation beginning in the 2010 time frame.

We recommend that research be performed to develop standards for addressing and routing schemes that would support the creation of a virtual voice/data network. Furthermore, research should be conducted to determine whether standards could be developed to support the integration of voice and data. If this is possible, it would allow maximum utilization of the VHF spectrum.

## **CPC Ground Communications**

No change is required to the ground communications systems until the deployment of VDL-3. At that time, digitization of controller voice will be required. To support this, we recommend that research be done to create improved standards for voice compression.

### **3.5 Controller Pilot Data Link Communication (CPDLC) Transition**

The objective of CPDLC is to provide a data messaging capability between controllers and pilots that will reduce voice frequency congestion and provide a more precise and efficient means of communicating clearances and advisories. CPDLC begins with the creation and initiation of a message by a controller or pilot. CPDLC messages are ATN compliant, which accommodates message prioritization. Fixed or free-text messages are supported. For operations in the continental US, CPDLC will initially utilize a commercial service provider with VDL-2 communications.

CPDLC has been identified as the means for automated delivery of hazardous weather alerts to the cockpit. Given the urgency associated with providing these alerts the current belief is that these messages must be prioritized for delivery. The VDL-2 implementation, does not support message prioritization at the RF level and it is unlikely that the NEXCOM implementation of VDL-3 for data can be accelerated into the 2007 time frame. In the interim, however, research could be performed to determine if priority messages could be integrated into the VDL-2 link. Standards work also can be performed to add hazardous weather messages to the CPDLC message set for use when NEXCOM/VDL-3 is implemented. Finally, research could be performed to promote a standard for a cockpit voice synthesis capability that would provide audio delivery of CPDLC messages.

The transition schedule for CPDLC is shown in Figure 3.5-1

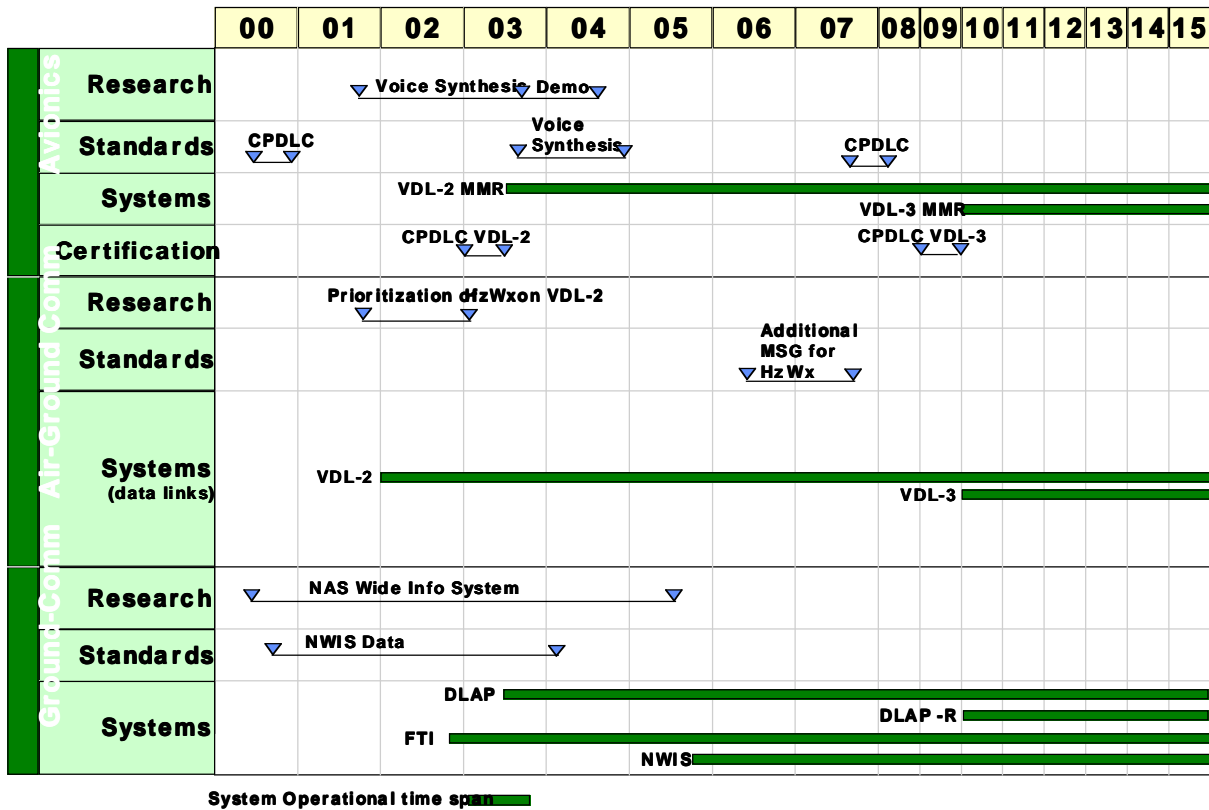


Figure 3.5-1. AATT Communication Architecture Schedule-CPDLC

### CPDLC Avionics

The exchange of controller pilot messages will begin in the mid 2003 time frame with a limited number of messages available in selected en route airspace using a commercial service provider's VDL-2 network. The available message set will continue to grow through transition to the FAA VDL-3 network based on demand. Aircraft operators that equip their aircraft for CPDLC via VDL-2 will be required to upgrade their radios for CPDLC via VDL-3 to be able to use the enhanced message set.

We believe that the use of synthesized voice (for delivery of selected CPDLC messages) in the cockpit would enhance safety by eliminating some pilot "head-down" time. Accordingly, we recommend research and demonstration of this capability that would lead to the development of a standard for the use of synthesized voice.

### CPDLC Air-Ground Communications

The VDL-2 network necessary to support initial CPDLC will be available in the 2002 time frame. We have recommended that CPDLC messages be used to support the delivery of hazardous weather advisories to pilots. As discussed above, these are considered priority messages that would only be suitable for delivery via VDL-3. Accordingly, we believe that research should be performed to determine the viability of sending hazardous weather advisories via VDL-2, given that VDL-2 ground networks support ATN priority. If successful, this would accelerate the benefits to both pilots and controllers.

Regardless of whether hazardous weather messages can be integrated into the VDL-2 message set, standards work will be required to establish the message set(s) for delivery via VDL-3.

### **CPDLC Ground Communications**

The processing of CPDLC messages on the ground requires a data link applications processor (DLAP) that must be kept up to date with the latest message set. Messages are delivered from the air-ground communications site to the appropriate ATC facility via the FTI network. An upgrade to the DLAP will be required to support the CPDLC message set when the transition to VDL-3 occurs in the 2010 time frame.

### **3.6 Decision Support System Data Link (DSSDL) Transition**

As we establish the NAS-Wide Information System and promote the exchange of common data among participating nodes of the NAS, a data exchange method must be created that allows aircraft to participate as if they were “ground-based” nodes (i.e., they would have the same access and integrity of information as ground nodes). This is the objective of DSSDL. DSSDL provides a capability for the transfer of data between aircraft avionics and ATC automation (or other aircraft). Its purpose is to accommodate real time exchange of data that does not require human intervention or acknowledgement. The data transferred by DSSDL supports calculations by DSS algorithms that will be used by controllers and pilots to make decisions. Initially, this data exchange is not fully automated in that the controller or pilot must authorize its use by the aircraft DSS/ATC DSS, which is similar to the exchange and use of pre-departure clearance data today. In time, however, with system experience and the acceptance of controllers and pilots, DSSDL will become a fully automated method of negotiating/notifying change among participating users of the NAS.

DSSDL is applicable only to aircraft that have an advanced FMS that supports integration with an onboard data link. In the 2007 time frame, the NAS will be in the initial stages of implementing DSSDL and only a small portion of class 3 users are expected to be equipped. Initial DSSDL messages most likely will be aircraft-to-ATC only, indicating preferences for routes or arrival times.

In the 2007 time frame, the NAS Architecture will be in the initial implementation stages of DSSDL. In this time frame, only aircraft preference data will be sent to ATC automation for controller use and for input to DSS tools. In fact, in the early stages of DSSDL the data exchange could be performed as message additions to AOCDL (using the extended message format) with routing to ATC. DSSDL data exchange will be via VDL-2.

The transition schedule for DSSDL is shown in Figure 3.6-1.



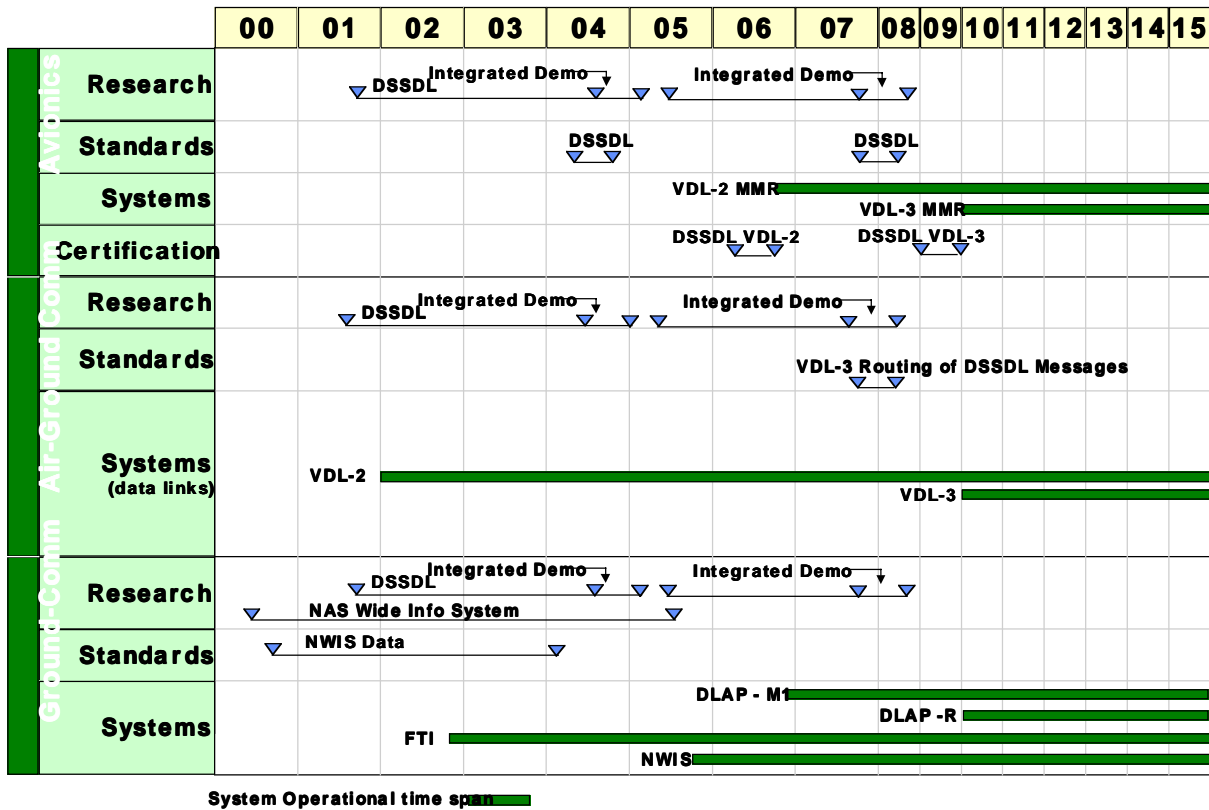


Figure 3.6-1. AATT Communication Architecture Schedule-DSSDL

### DSSDL Avionics

Deployment of an initial aircraft to ATC DSSDL capability in the 2006/2007 time frame will require research and demonstration of an integrated avionics, air-ground communications, and ground communications system. The results of this research and demonstration will be used to establish standards for the initial deployment of DSSDL. Following this initial research, further research should be conducted to establish the aircraft to aircraft data exchange standard using VDL-3 with the goal of establishing a syntax for negotiation based on a defined information base shared by each party to the negotiation. Transition to DSSDL via VDL-3 will occur in the 2010 time frame in conjunction with the transition of NEXCOM and CPDLC.

### DSSDL Air-Ground Communications

DSSDL will utilize the existing commercial service provider VDL-2 network and will transition to the FAA VDL-3 network in the 2010 time frame. Integrated research must be conducted to support the deployment of this capability as discussed above.

### DSSDL Ground Communications

A modification to the DLAP will be required in the 2006 time frame in order to support the initial DSSDL data exchange. Messages are delivered from the air-ground communications site to the appropriate ATC facility via the FTI network.

### **3.7 Aeronautical Operational Control Data Link (AOCDL) Transition**

Aircraft Operational Control (AOC) – Pilot/Aircraft – AOC data exchange supports efficient air carrier/air transport operations and maintenance. The AOC’s prime responsibility is to ensure the safety of flight and to operate the aircraft fleet in a legal and efficient manner. The AOC’s business responsibility requires that the dispatcher conduct individual flights (and the entire schedule) efficiently to enhance the business success and profitability of the airline. Most major airlines operate a centralized AOC function at an operations center that is responsible for worldwide operations. Typical AOC data exchange supports airline operations (OOOI, flight data, position reporting, etc.) and maintenance (performance, diagnostic, etc.).

In the 2007 time frame the AOCDL begins to take on increasing significance as a part of the collaborative decision making process between ATC, AOC, and the aircraft. A majority of current ACARS users will migrate to VDL-2 because of the additional data capacity provided.

In 2015, the AOCDL continues to provide operations and maintenance data exchange service via VDL-2.

The AOCDL transition schedule mirrors that of the VDL-2 communications link described in Section 4.2 of this document.

### **3.8 Automatic Dependent Surveillance (ADS-B) Transition**

ADS-B aircraft continuously broadcast their position, velocity, and intent information using GPS as the primary source of navigation data to enable optimum maneuvering. ADS-B will support both air-ground and air-air surveillance. The major operational environments improved by ADS-B include “gap-filler” surveillance for non-radar areas, surface operations, pair-wise maneuvers, and approach/departure maneuvers. ADS-B equipped aircraft with CDTI equipment will provide enhanced visual acquisition of other ADS-B equipped aircraft to pilots for situational awareness and collision avoidance. Pilots and controllers will have common situational awareness for shared separation responsibility to improve safety and efficiency. When operationally advantageous, pilots in ADS-B equipped aircraft may obtain approval from controllers for pair-wise or approach/departure maneuvers. In the future, en route controllers in centers with significant radar coverage gaps will provide more efficient tactical separation to ADS-B equipped aircraft in non-radar areas. The received ADS-B surveillance data will enable controllers to “see” ADS-B equipped aircraft and reduce separation standards in areas where they previously used procedural control.

ADS-B will be deployed in a phased approach consistent with aviation community needs, FAA priorities, and projected budgets. In general, for each ADS-B operational environment, experiments and prototype demonstrations conducted as part of Safe Flight 21 lead to operational key site deployments. Key site deployments represent the increment where operational procedures and certified systems are used to deliver daily service. Following key site deployment, additional “pockets” of ADS-B will be deployed on a benefits-driven basis. These deployments eventually could result in national deployment. In the 2007 time frame, initial deployment will be started for the “pocket” areas. Much of the initial ADS-B deployment will enable air-to-air use of ADS-B in selected airspace to demonstrate operational feasibility and achievement of estimated benefits. The extent of aircraft equipage and demand from the aviation community will be a factor in determining the strategy for deployment of ADS-B ground stations.

The FAA is engaging in a program to evaluate three candidate ADS-B communication technologies (Mode S Squitter, UAT, VDL-4) with an expected link decision in 2001.

The transition schedule for ADS-B is shown in Figure 3.8-1.

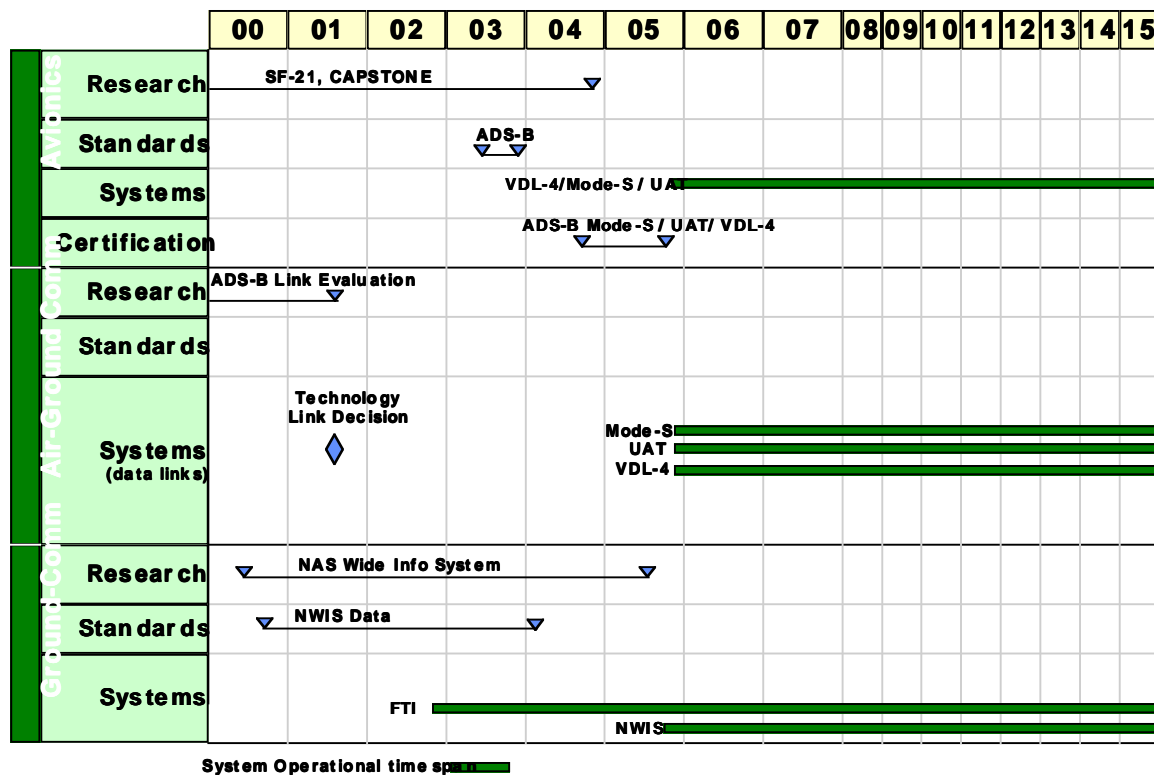


Figure 3.8-1. AATT Communication Architecture Schedule-ADS-B

### ADS-B Avionics, Air-Ground Communications, and Ground Communications

The transition of ADS-B is being conducted by the Safe Flight 21 program office with field evaluations being conducted in Alaska and the Ohio Valley region. The results of these ongoing field trials will be input to a link decision in the late 2001 time frame. The result of the link decision will begin a series of “local pocket” implementations throughout the NAS beginning in the 2005/2006 time frame. Research in this area is mature and well defined.

### 3.9 Automated Meteorological Transmission (AUTOMET) Transition

AUTOMET is being defined under the auspices of the RTCA SC 194, which established the Minimum Interoperability Standard (MIS) for Automated Meteorological Transmission for wind, temperature, water vapor and turbulence. Conceptually, aircraft participating in an AUTOMET service program must be able to respond to AUTOMET commands issued by a ground-based command and control system. Downlink message parameters (e.g., frequency, type, etc) are changed by uplink commands from the ground-based systems and are triggered by various conditions (agreed to in advance by the airline, service provider and NWS), or by a request from an end user. Goals of the AUTOMET system are: 1) Increase the amount of usable weather data that is provided to the weather user community; 2) Increase the resolution of reports, forecast products and hazardous weather warnings to make providers of weather information more

operationally efficient; 3) Increase the knowledge of the state of the atmosphere and decrease controller workload by automatically transmitting hazardous weather conditions to the ground and other aircraft to improve the ATC system.

Participating aircraft that report weather using AUTOMET collect wind, temperature, humidity, and turbulence information in flight and automatically relay the information to a commercial service provider using VDL Mode 2. The service provider collects and reformats the information and then forwards the information to the National Weather Service (NWS) and the FAA. The NWS uses this AUTOMET information and weather data from other sources to generate gridded weather forecasts. The improved forecasts are distributed to airlines and the FAA to assist in planning flight operations. The gridded weather data, based on AUTOMET data, is also provided to WARP for use by FAA meteorologists and is used by several ATC decision support system tools to improve their performance.

The transition schedule for AUTOMET is shown in Figure 3.9-1.

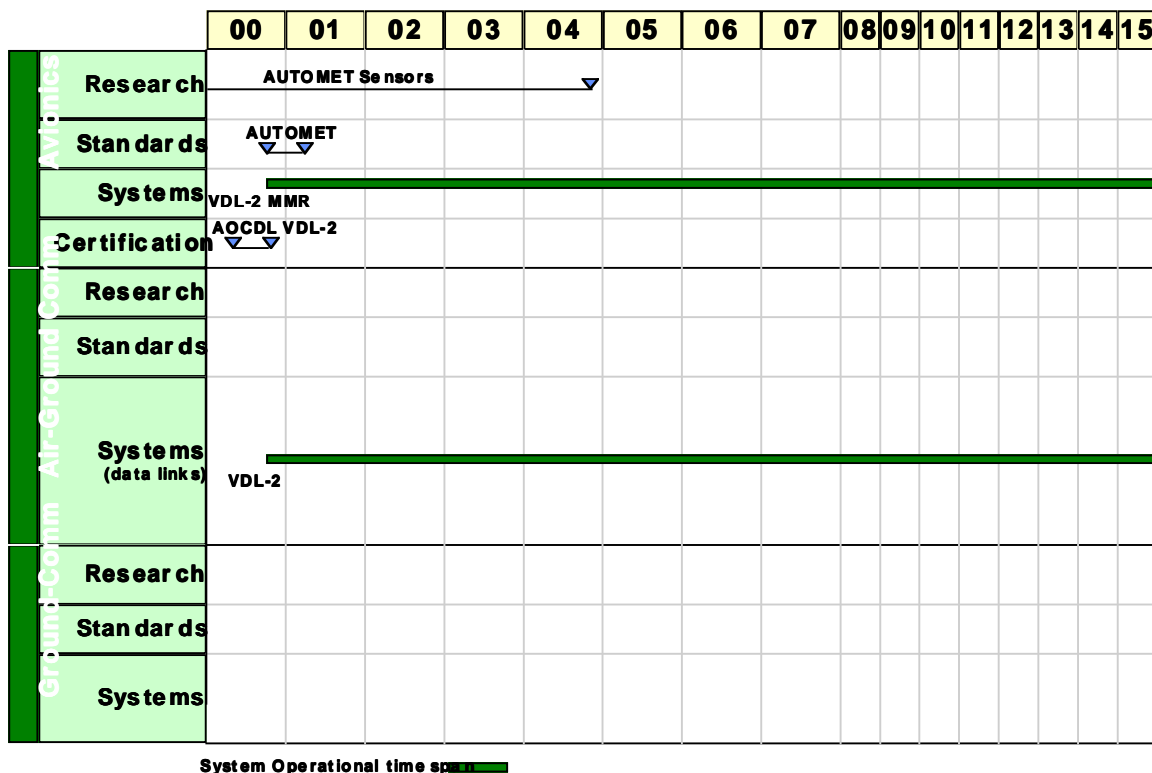


Figure 3.9-1. AATT Communication Architecture Schedule-AUTOMET

## **AUTOMET Avionics**

There is ongoing research on AUTOMET avionics sensors in addition to the standards work described above. Calibration requirements for sensors on low end GA aircraft is seen as an obstacle for widespread implementation. The amount of data that is required and how the data will be used is yet to be determined.

### **3.10 Aeronautical Passenger Services (APAXS) Transition**

Passengers enjoy in-flight television, radio, entertainment, telephone, and Internet services. Our analysis of communication trends indicates that there will be a commercial demand for real-time television, radio, and Internet service to airline passengers. Industry surveys have shown that while prerecorded programs and movies are a lower priority for passengers than reading, sleeping, and working, there always has been a high interest in live television. One service provider had surveys conducted that showed some 50% of respondents were interested, and 35% would be willing to pay \$3-5 per flight for live television--the principal interest being in CNN. This demand for service most likely will be satisfied through digital, high-data-rate satellite channels.

While APAXS is not a service associated with any air traffic management function, it is likely that in the 2007 time frame commercial demand will have driven direct broadcast satellite service to be available in the cabin. This availability is particularly important to note since it may provide an opportunity to support air traffic services that would not be possible otherwise.

The transition schedule for APAXS is expected to follow the SATCOM schedule described in Section 4.6 of this document.

## 4 Communication Link Transitions

The previous section addressed the transition issues from the perspective of the major service concepts. This section addresses the transition milestones and activities from the data link technology point of view.

### 4.1 VHF-AM Transition

In 2007 there is still total reliance on VHF-AM for controller pilot voice communication in the terminal and airport domains. However, we anticipate that as a result of successful PETAL-II trials in Europe and CPDLC trials in the US, a majority of class 2 and 3 aircraft operators will upgrade their communication avionics to VDL-2 multimode radios to take advantage of CPDLC in the En Route domain.

In 2015 the NAS will have transitioned from VHF-AM for controller pilot voice communication to VDL-3 digital voice communication in all but selected areas of uncontrolled airspace. Additionally, for Class 2 and 3 users, the majority of controller pilot communication occurs through CPDLC via VDL-3.

The transition schedule for VHF-AM is shown in Figure 4.1-1.

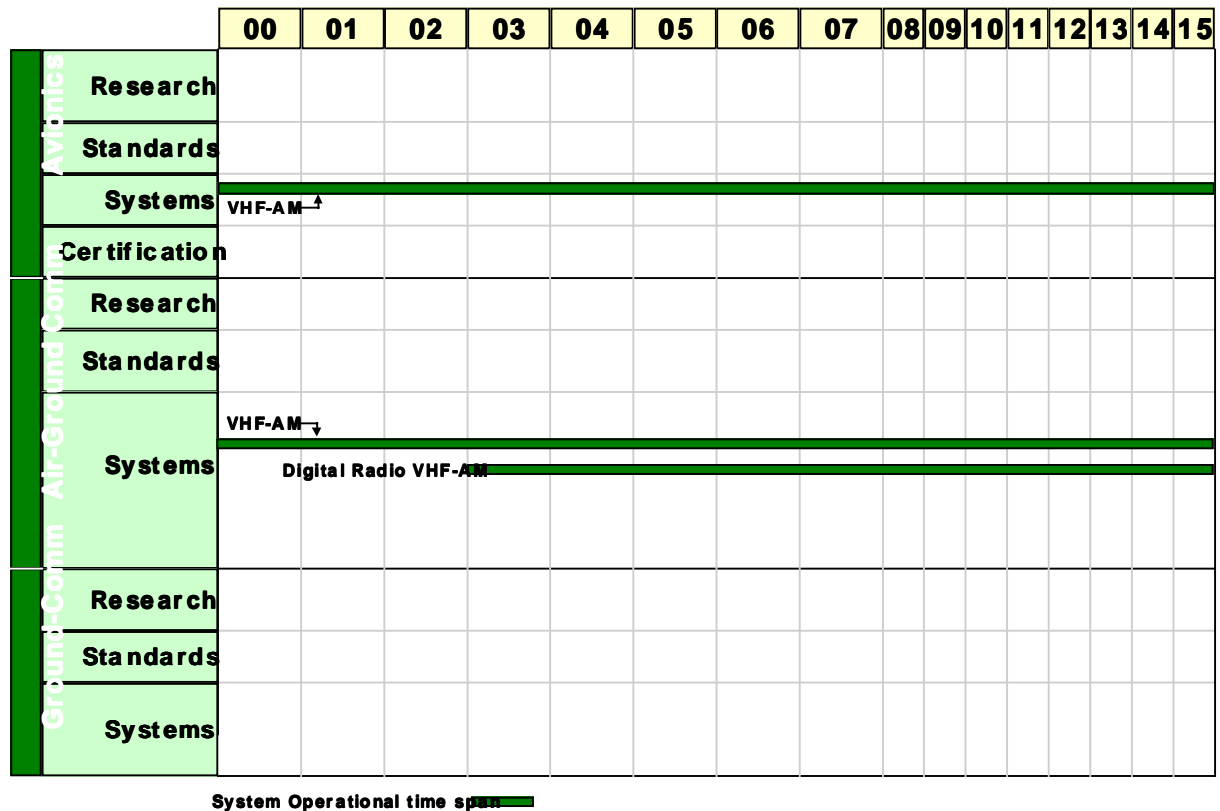


Figure 4.1-1. AATT Communication Architecture Schedule-VFH-AM

## 4.2 VDL-2 Transition

In addition to CPDLC, the benefit of data link also increases the use of VDL-2 for DSSDL and AUTOMET in addition to supporting its original service of AOC DL. In this time frame, all VDL-2 data is transmitted via the AOC frequencies. The anticipated number of channels assigned for VDL-2 AOC use is four. This provides an effective total data rate of 126Kbps. Our worst case estimate for VDL-2 data in this time frame is 104Kbps (see section 4). Based on that estimate, we believe that there is sufficient margin available to support the interim use of the AOC VDL-2 network for CPDLC, DSSDL, and AUTOMET. This data loading will shift to the FAA VDL-3 network in the 2015 architecture. AOC data is not permitted on the Government-owned ATC Communications links.

There will continue to be a need to maximize the communication capacity of VHF data links operating in the protected aviation spectrum. Accordingly we recommend further research in the areas of link modulation and data compression to increase the overall bit transfer rate, and network prioritization schemes that combine voice and data, and the development of designs for virtual air ground links that will maximize the use of available frequencies.

The transition schedule for VDL-2 is shown in Figure 4.2-1.

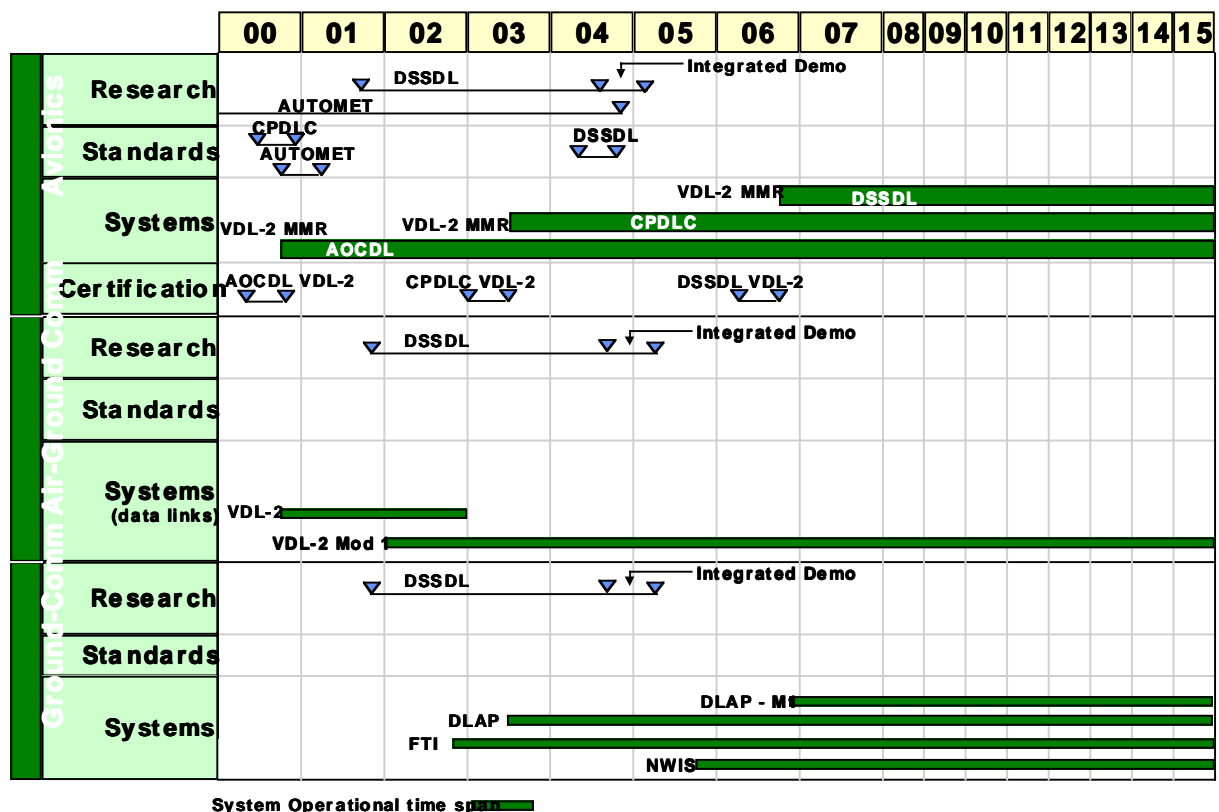


Figure 4.2-1. AATT Communication Architecture Schedule-VDL-2

## 4.3 VDL-3 Transition

VDL-3 provides a time division access scheme that accommodates message prioritization and provides subchannels that can be dedicated to either voice or data exchange. VDL-3 will be

deployed by the FAA beginning in the 2010 time frame at their existing air-ground communication sites. Selected airspace will be cut-over from VHF-AM to VDL-3 for voice (NEXCOM) and from VDL-2 to VDL-3 for data (CPDLC, DSSDL) through 2015.

There will continue to be a need to maximize the communication capacity of VHF data links operating in the protected aviation spectrum. Accordingly we recommend further research in the areas of link modulation and data compression to increase the overall bit transfer rate, and network prioritization schemes that combine voice and data, and the development of designs for virtual air ground links that will maximize the use of available frequencies.

The transition schedule for VDL-3 is shown in Figure 4.3-1.

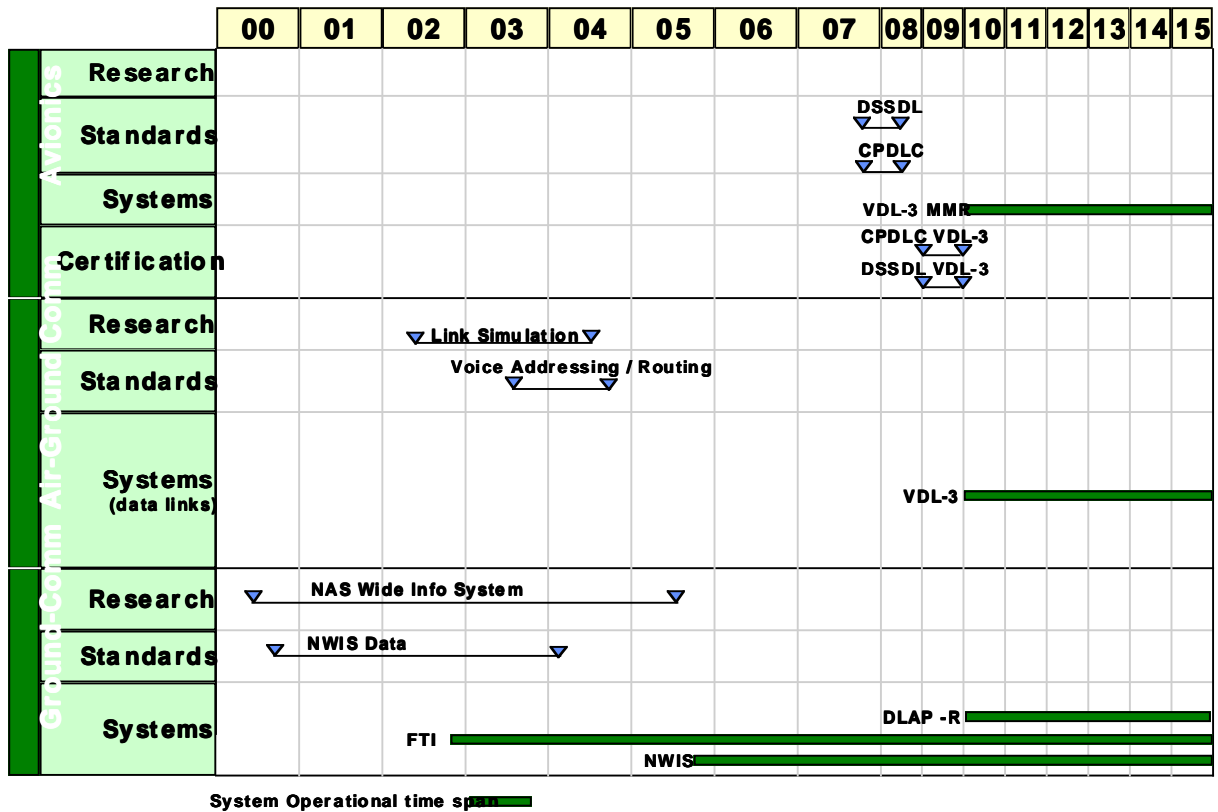


Figure 4.3-1. AATT Communication Architecture Schedule-VDL-3

#### 4.4 VDL-B Transition

Commercial service providers are anticipated to employ some form of VDL Broadcast for support of FIS. Research should be conducted to determine the suitability of VDL-B for support of TIS. This research should also consider the use of single or multiple VDL-3 subchannels for data broadcast in both air-to-air and air-to-ground applications. Additionally, research should be conducted to determine the improvements that can be made in the effective data transfer rates for FIS (and possibly TIS) through the use of data compression schemes.

The transition schedule for VDL-B is shown in Figure 4.4-1.



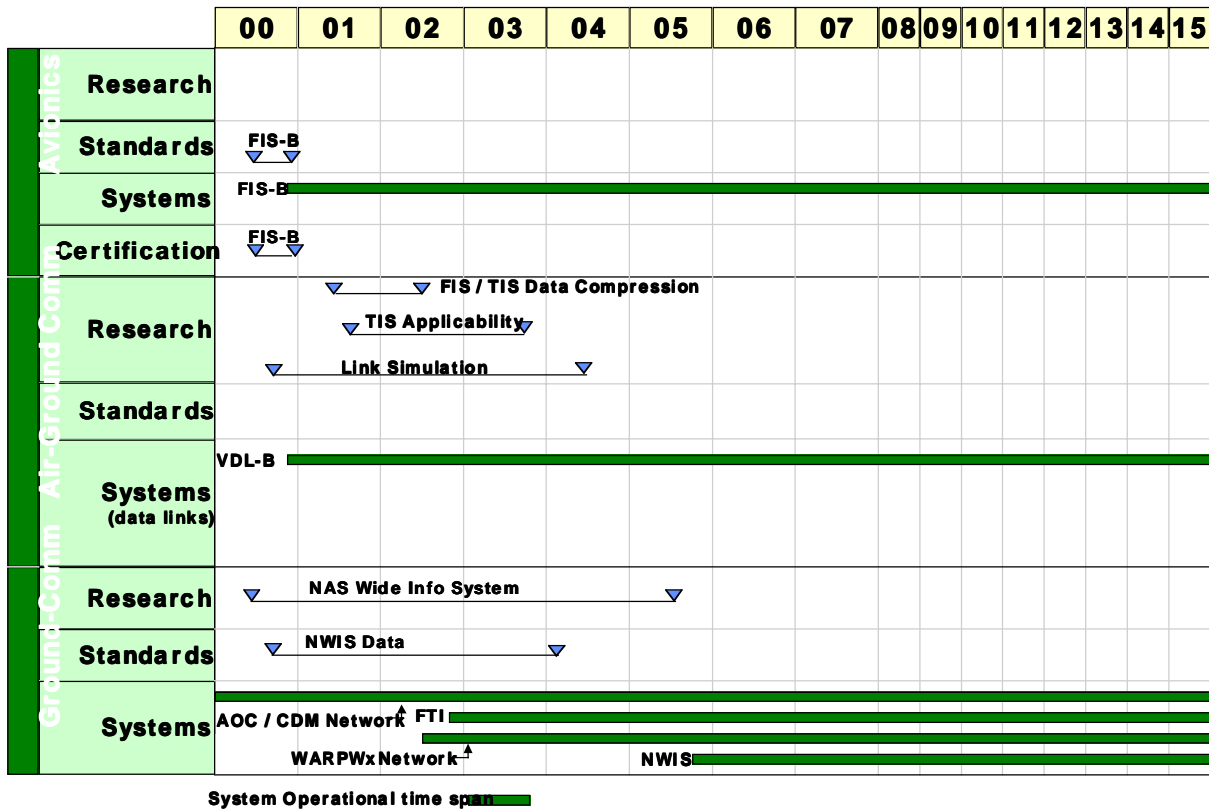


Figure 4.4-1. AATT Communication Architecture Schedule-VDL-B

#### 4.5 VDL-4, UAT, Mode-S Transition

The use of Mode-S and VDL-4 as data links should—in our opinion—be dedicated solely to the support of surveillance in order to optimize the use of these links for that purpose. This would limit these links to the support of ADS-B (in addition to the secondary surveillance function in the case of Mode-S). While these links could arguably support any data exchange between air and ground, we do not feel that it makes sense to burden these links with non-surveillance data when there is sufficient (and more suitable) broadband capacity on other links. While UAT provides a broadband data link capacity, we would also recommend that, if selected for ADS-B, consideration be given to use of a dedicated frequency for ADS-B with additional frequencies allocated for broadband data exchange. The FAA and EUROCONTROL are currently in the process of making a link decision for support of ADS-B.

The transition schedule for VDL-4/UAT/Mode-S is shown in Figure 4.5-1.

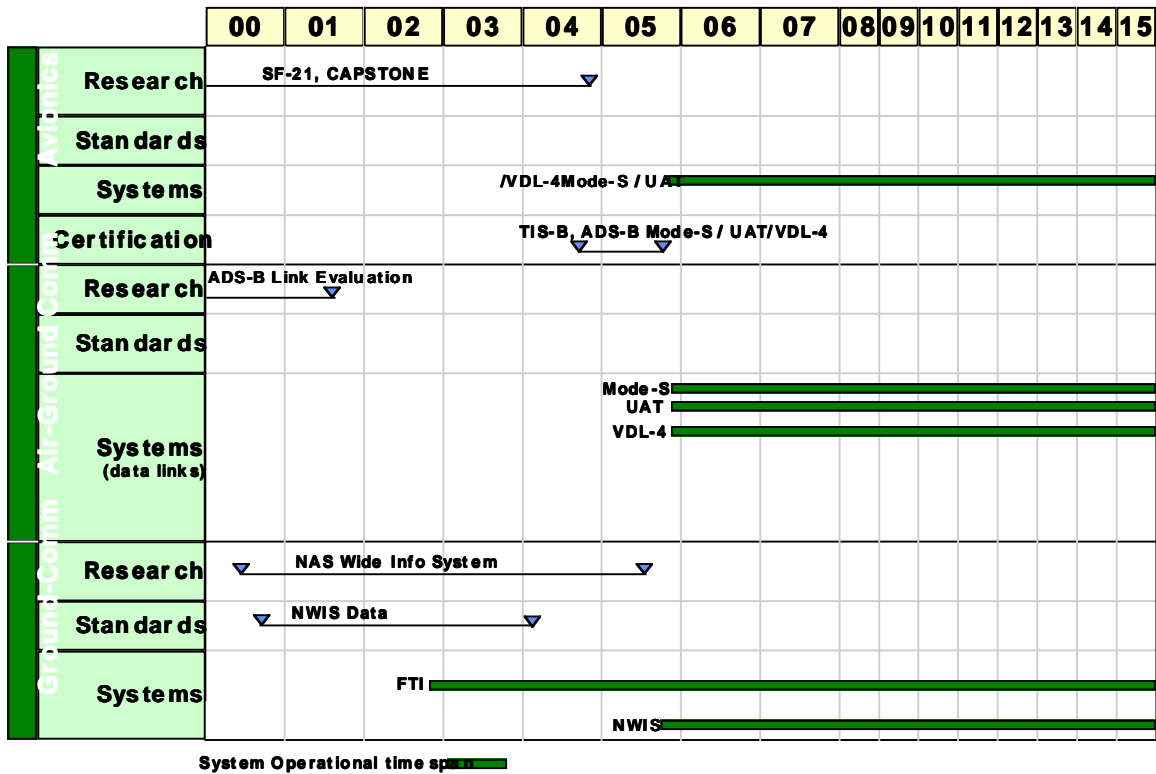


Figure 4.5-1. AATT Communication Architecture Schedule-UAT/Mode-S/VDL-4

#### 4.6 SATCOM Transition

Finally, the use of SATCOM will be driven by the commercial sectors desire to provide high-data-rate services to passengers such as real time television and Internet. Air Traffic Service providers should stay aware of these efforts and look for opportunities to exploit this method of data transmission to support the broadcast needs of TIS and FIS.

Accordingly, we recommend that further study be conducted to determine the possibility for innovative partnerships or incentives that may leverage the involvement of commercial service providers in the delivery of selected air traffic services via SATCOM. For example, providers of broadcast entertainment channels to aircraft could be required to provide an air traffic services channel that is freely accessible by all aircraft. This example is similar to the requirement that cable television providers have with regard to providing public access channels.

The transition schedule for SATCOM is shown in Figure 4.6-1.

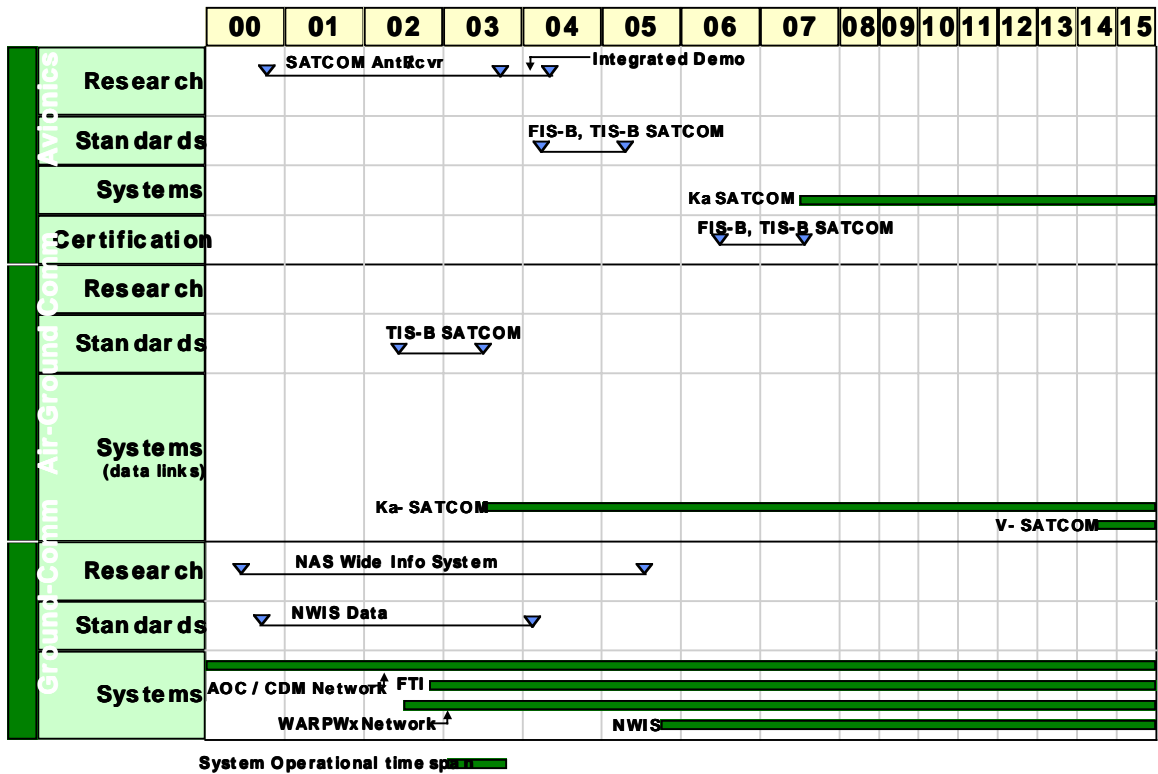


Figure 4.6-1. AATT Communication Architecture Schedule-SATCOM

## **5 Communication System Cross-cutting Transition activities**

The integration of tools, services, technologies, procedures and information will provide the necessary foundation to support the 2015 AATT concept. A comprehensive communications system architecture must facilitate the interaction and integration of multiple services. The cross-cutting technology issues that will impact the communications architecture apply to more than one service and are media independent. These include the detailed definitions of the NAS-wide Information System, Information Security and Information Display.

### **NAS-wide Information System**

- Definition of a common data set
- Standardized interfaces to promote interoperability
- Performance parameters

### **Information Security**

- Encryption techniques (as applicable to various types of data)
- Performance requirements
- Protection from unauthorized access
- Protection from interference

### **Information Display**

- Fused display of flight, traffic, taxi information
- Standard symbology
- Low cost, multifunction displays

The transition schedule for Communication System Cross-cutting activities is shown in Figure 5-1. The schedule includes a summary of the air-ground and ground communication systems that are affected by these cross-cutting activities.



## **6 Summary**

When applicable, the milestones and associated activities discussed in this transition plan are based on the current implementation schedules for products and services identified in the NAS Architecture. For services that are outside of the NAS transition plan (AOC, Onboard Passenger/Crew) and new transmission links (Ka-band SATCOM) the schedules have been derived from knowledge of FCC filings and current research and development efforts by commercial service providers. The gaps identified in this section are addressed in further detail in task 10 and task 11.